The Care of the Cell

Onomatopoeia and Embodiment in a Stem Cell Laboratory

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Introduction

In 2007, Japanese medical scientist Shinya Yamanaka and his group at Kyoto University created a new kind of artificial human stem cell. By creating iPS (induced pluripotent stem) cells from human skin cells, the Yamanaka group demonstrated that mature cells can be converted to stem cells. For this research, Yamanaka was awarded the 2012 Nobel Prize for Physiology or Medicine. Meanwhile, iPS cells have opened up new possibilities in biology, embryology, toxicology, pharmacy, regenerative medicine and many other fields.

This paper mainly focuses on researchers who are working to apply iPS cell *technology* in regenerative medicine. The rapid progress of iPS cell technology has made it possible to acquire various kinds of cells and tissue through genetic and chemical manipulation of stem cells. In the newly emerging field of regenerative medicine, combining biological, embryological, genetic, and medical knowledge, researchers have been trying to develop transplantable tissues to cure diseases and injury. Here, they face the challenges of so-called 'translational research' involving two-way traffic between basic research (bench) and clinical practice (bedside). As many social scientists have noted (e.g. Franklin 2005), stem cell technology is worth analyzing for what it tells us about the transformation of society and biotechnology.

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In this paper, I explore how scientists and support technicians produce new medical technologies by using and manipulating 'life itself' (Rose 2006). In stem cell research and regenerative medicine the aim is to rebuild damaged tissue using *manipulated* cells. Thus, by contrast with organ transplantation, stem cell researchers and technical staff manipulate cells genetically or chemically and culture them in petri dishes for a certain period of time. How do scientists actually make cells as 'tools' or 'products' from living human bodies? How do scientists evaluate cells in dishes (*in vitro*) and cells in bodies (*in vivo*)? Results from my fieldwork in one of Japan's leading stem cell laboratories suggest that regenerative medicine is a particularly useful perspective for rethinking the boundaries between *in vivo* and *in vitro*, medicine and science, organism and instrument.

Cells are one of the most important experimental tools for current life science and medical investigations. Drawing on Michel Foucault, Karl Marx, and Max Weber, many STS scholars have discussed how life in the age of genomics has become enmeshed in market dynamics. Kaushik S. Rajan (2006), for example, proposes the concept of 'biocapital' to describe how life is commoditized at the molecular level. The concept of biocapital is linked to 'biovalue,' a term deployed in an analysis of stem cell technologies by Catharin Waldby (2002) to refer to 'the yield of vitality produced by the biotechnical reformulation of living processes' (2002: 310). Objects in the life sciences have been reduced to their minimal components: e.g., molecules, genetic material, proteins, and cells. At the microscale, this reduction enables precise calculation and subsequently intervention in life itself: for example, new species are being created by gene modification and genetic testing has facilitated diagnosis of certain diseases. Focusing on this process of reduction, STS scholars tend to emphasize the unilateral development of biotechnology toward standardization and commodification. While it is true that such tendencies exist in this era of 'biomedicalization' [1] (Clarke et al. 2003), scholars have paid far less attention to how bio-materiality is itself remade in the laboratory. When we look closely at what scientists actually do, however, we can see that domesticating life itself and standardizing the products of advanced cell technology are by no means straightforward or easy.[2]

1 Clarke et al. (2003) proposed the concept 'biomedicalization' for technoscientific transformations that have occurred since about 1985. They discuss five interactive processes involving 'the increasingly technological and scientific nature of biomedicine' and 'transformations in how biomedical knowledge are produced, distributed, and consumed, and in medical information management' (2003: 161).

2 Stefan Helmreich (2008) also points to similar problems. In his ethnography Alien Ocean: Anthropological Voyages in Microbial Seas (2009), he shows how biological life forms and social and cultural forms of life are entangled through description of scientific activities in marine microbiology.

This paper is informed by Andrew Pickering's account of scientific practice, which shows humans and nonhumans interacting in an open-ended process of scientific experimentation in scientific laboratories, something Pickering describes as 'the dance of agency' (Pickering 1995). In the stem cell laboratory, cells are instruments for experiment and at the same time living beings, which sometimes 'resist' standardization and spiral out of control. Indeed, cells both need and demand attention and commitment from scientists and technical staff. Exploring emerging liveliness in the laboratory environment, this paper describes how scientists and technicians *care for* their cells and develop affective relations with them.

In what follows, by expanding the notion of experimental systems (Rheinberger 1997) and bringing together the emerging field of affect studies and care in STS, I explore how stem cells oscillate, in a Japanese stem cell laboratory, between liveliness and instrumentality, how they draw the people around them into complex and sometimes unexpected human/non-human relations.

Experimental Systems, Care and Affect

To shed light on the oscillation between liveliness and instrumentality of cells in practices of medical technology, this paper first draws on Hans-Jörg Rheinberger's (1997) discussion of the construction of an in virto system of protein biosynthesis and emergence of transfer RNA in the laboratory. For Rheinberger, the 'experimental system' is the core structure of scientific activity. In his words, '[e]xperimental systems are the basic units of the scientific tracing-game. Within a framework of technical things taken for granted, they provide the conditions for the generation of epistemic things. Such systems must be capable of being differentially reproduced in order to serve and behave as machines for generating the future' (1997: 224).

In this account, experimental systems are 'hybrid constructions … at once local, social, technical, institutional, instrumental, and epistemic settings' (1997: 34). This paper expands this notion of experimental systems primarily in two directions. First, it reconsiders the experimental instrument as a living technology. Second, inspired by the work of Natasha Myers and Joe Dumit (2011), I pay attention to the bodily engagement of scientists and to their language. In this project, I am interested in the *in-betweenness* of cells and scientists.

In the life sciences, experimental systems are often composed of living technologies. Hannah Landecker (2007) historically explores how cells become technological tools in the laboratory environment. She argues that 'living technologies such as flies, mice, and cultured cells are part of the attempt to stabilize the innate flux and variation of living things as well as to simplify and standardize

the objects of research as much as possible. … Genetically and physically reshaped living matter plays an infrastructural role in making biology the same over time and space' (2007: 25–6).

Obviously, living technologies are not literally machines. Living technology is closer to some kind of quasi-organism and quasi-instrument. In life science laboratories, scientists use chemicals, cells, and mice and rats, and various other materials, apparatus, and instruments required for making controlled changes to living organic matter; all of the materials, including chemicals and cell culture media, are part of 'living technologies' and require proper treatment.[3] For instance, cell culture media are extracted from cow serum and immunostaining chemicals are made from the living organs of rabbits, mice, and goats. These and a vast number of other living technologies have been developed as laboratory tools, but most do not come in use-as-is packages: in their ongoing experiments, scientists and technical staff need to, on the spot, prepare and attend to living technologies with due care in handling, maneuvering, and manipulation. In this context, the care of living animals or living tissues is an essential part of life science. Because these technologies are living and thus highly sensitive to changes in the environment, without proper care, they do not function well as tools: indeed, without this care, they would perish.

Because human iPS cell research first began in 2007, the iPS cells used for application in regenerative medicine are yet to be standardized. Furthermore, in translational research, medical scientists cannot directly apply the same cell lines or use the same techniques as in basic experimental science. Drawing on basic biology, embryology, and stem cell science, medical scientists need to develop experimental systems that are suitable for the clinic. Working on different problems, they modify and channel living, that is, iPS cell, technology in directions distinct from those taken by basic science.

Indeed, I argue that care is one of most important concepts for understanding how people and cells interact at the bench. To elaborate this point, I turn to Maria Puig de la Bellacasa's work on matters of care among humans and non-humans (2011). Drawing on Bruno Latour's notion of 'matters of concern', she argues that the notion of 'matters of care' offers a more precise characterization of certain forms of practice, since care 'has stronger affective and ethical connotations' (2011: 89) than concern. Care contains not only 'worry and thoughtfulness about an issue' (2011: 89) but also 'a strong sense of attachment and commitment to something' (2011: 89–90). In this sense, care involves both affective and, as I discuss below, kinesthetic entanglement.

3 Chemicals in laboratories have specified storage temperatures and use-by dates.

As a backdrop to the exploration of scientists' care of their cells, it is important to consider the relation between care and some recent theories of bodily affect. Anthropologist Natasha Myers (2008 & 2015) argues that knowledge production depends on embodied and gestural skills. In her ethnography of protein crystallographers, Myers insists that despite the rapid development of scientific imaging technologies, crystallographers continue to use their bodies in order to understand the extremely complicated three-dimensional structure of proteins. She vividly describes how a female crystallographer 'contorts her entire body into the shape of the misfolded protein. With one arm bent over above her head, another wrapping around the front of her body, her neck crooked to the side, and her body twisting, she expresses the strain felt by the misshapen protein model' (2008: 165).

In another article co-authored with Joe Dumit (2011) she proposes a notion of 'haptic creativity'. In addition to the local, instrumental, institutional and technical dimensions of their work, scientists engage kinesthetically and affectively 'with objects and instruments and the ongoing transformation of their modes of embodiment inside of their experiments' (2011: 249). Myers and Dumit show that scientists are involved in scientific imaging technology and that they innovate through their improvisational and bodily movement. Inspired by Bruno Latour's notion of 'becoming articulate' (2004)[4], they show how cell biologist Dan Hijiko (pseudonym) '*invents a new mode of seeing*' (Myers & Dumit 2011: 252). Dan holds an invisible picture 'in front of him and he leans forward with narrowed eyes, mimicking the mannerism of his mentor' (2011: 251). Through this process, Dan starts to get interested and involved in the object under study. Then, he goes to the next level of the new mode of seeing. By repeating this practice of mimicry, 'Dan wasn't just trained 'mentally'. Having articulated a habitus, being mid-embodiment and searching for new embodiments, he gets entrained on phenomena that have the capacity to excite his sensorium' (2011: 252). Myers and Dumit call this 'improvisational play as bodies (human, nonhuman and machine) and meanings get made' (2011: 244) in scientific experiments 'haptic creativity'.

Observations in my own research are similar to those of Myers and Dumit: scientists and technical staff caring for stem cells invent a new mode of seeing as they create new technologies of life itself. As I will show, these laboratory members become affected by their cells through the process of modifying their potential for affecting them, becoming involved in and enacting processes that we might also term haptic creativity.

4 Latour (2004) discusses the case of training 'noses' for the perfume industry. Through the use of odour kits, trainees acquire a 'nose' by 'learning to be affected'. Slowly, they learn to discriminate subtle differences of smell and become able to tell them apart from one another.

Method

Empirically approaching kinesthetic and affective entanglement involving care and affect causes methodological problems. For example, the culturing of cells involves both tacit knowledge and tacit care, and both are difficult for scientists to convey to the researcher in verbal form. Thus, there are clear methodological limitations to relying exclusively on interviews. I have tried to circumvent this problem by using multiple methods: participant observation, interviews and learning to experience the cells myself.[5]

Since September 2012, I have been conducting fieldwork in a stem cell laboratory in Western Japan. The Murakami Laboratory[6] belongs to a world famous research institute of developmental biology. The principle investigator, Yoko Murakami[7] is a female 'clinician-scientist'[8] who aims to create new treatments 'from bench to bedside'.[9] Currently, the laboratory is trying to find cures for eye disease using stem cells, such as ES (embryonic stem) cells, neural stem cells and iPS cells.

Information presented in this article draws on participant observation I have conducted in the cultivation rooms two or three times a week since arriving at the laboratory, and on what informants have told me during almost 20 formal and semiformal interviews with scientists, technical staff, clinicians, and Ph.D. students inside and outside of the laboratory premises.

The Practice of the 'iPS Sommelier'

Experimental Systems and Methods/practice of Caring for Cells

The Murakami Laboratory is not a basic science laboratory. Rather, the laboratory aims to develop new medical technologies for regenerative medicine.[10] Murakami's main interest is in making, *in vitro*, parts of the eye for transplantation, which will compensate for and activate lost functions. The target diseases include age-related macular degeneration and pigmentary degeneration of the retina.

5 Starting as a complete beginner, I learned cell cultivation from the lab members for two weeks.
6 Over 50 staff members belong to Murakami Lab. For instance, medical researchers (Ph.D. & M.D.), basic researchers from molecular biology or agriculture (Ph.D.), technicians who help with experiments, assistants, a patent attorney, and Ph.D. students from graduate schools of medicine.
7 Yoko Murakami is a pseudonym.
8 'Clinician scientists' engage in research and also see patients.
9 A more widely used term is 'translational research'.
10 Aside from regenerative medicine, the lab is developing a system of genetic diagnosis and research about the immune system in eyes. Basic scientists who are interested in eye development pursue their own themes.

It had been believed that a retina, once damaged by disease, could not recover by itself. Since the early 2000s, however, scientists have developed techniques to differentiate and culture specific parts of the human eye, such as RPE (retinal pigment epithelium), photoreceptor cells, and the retina itself by manipulating stem cells. [11] The relevant techniques of differentiation were discovered in the field of developmental biology of the neuron. In vertebrate embryonic development, the retina originates as an outgrowth of the developing brain. Neurologists tried to make neurons from stem cells and eventually cultured and acquired RPE and midbrain dopaminergic neurons by accident. This important technical advance was discovered as a spin-off of neurology (e.g., da Cruz et al. 2007; Dowling 2012; Ryan et al. 2013).

Murakami speculated that RPE or photoreceptor cells derived from stem cells could be used to cure patients with serious eye conditions. Through technology transfer from the neurology laboratory, the Murakami Laboratory established its own experimental system for regenerative medicine. But, rather than investigating molecular or cellular phenomena, its goal was to establish a new medical technology using 'life itself', i.e., stem cells. In the effort to make cells and organisms do something useful and behave as laboratory members want, the Murakami Laboratory has improved the efficiency of differentiation, developed model organisms, surgery techniques, new devices, and even regulatory systems. In this sense, the Murakami Laboratory has established a specific kind of experimental system.

Making and caring for cells are crucial aspects of this experimental system. Laboratory members culture various types of cells for use in experiments and for transplantation into experimental animals. Researchers take a particular interest in establishing procedures to artificially create parts of an eye, such as three dimensional retinas, RPE, photoreceptor cells, and various kinds of stem cell. Investigating how to make these cultured tissues compensate for loss of function when eye tissues are damaged or weakened, and seeking the optimal circumstances for transplantation, laboratory members have tested various conditions, including the specific treatment time or developmental stage of the cultured cells, the best time for transplantation according to on the condition of the host animal, the number of cells to use, and immune system status of the host. They have so far transplanted cells and tissues into laboratory animals, and in the near future, plan to transplant to human patients. In the laboratory, they have been observing how cells or tissues grown *in vitro* function in animal bodies.

11 In the 1980s and the 1990s, medical scientists tried to transplant various kinds of RPE, such as adult RPE and foetal or childhood RPE (e.g. de Crux et al. 2007).

In the laboratory, culturing iPS cells is especially difficult because they are particularly sensitive and can easily lose their pluripotency and become like any other somatic, 'non-pluripotent' cell.[12] Even if new laboratory members already know how to culture other kinds of cells, they have to be trained by experienced technicians to grow iPS cells. In the laboratory, some technicians and researchers are known for their skills in handling these cells especially well. Using a metaphor from the world of wine connoisseurship, these researchers are referred to as 'iPS sommeliers'.

As a trained and knowledgeable wine professional, a sommelier is able to select suitable wines for various dishes, based on considerations that may include the type of customers, the mood, the season, and, of course, the menu. In referring to her laboratory members in this way, Murakami draws attention to their skilled judgment and their ability to select the right iPS cells and RPE for use in experiments. Their judgment is essential in taking care of the cells.[13] Importantly, the ability to notice slight differences in cell condition and quality is assumed to be correlative with particular forms of attachment, love, and aesthetics.

Seeing the Faces of Cells

During my fieldwork, the laboratory recruited new technical staff and started training them to be iPS sommeliers. I seized this opportunity to observe the training. These novices were technical staff from other research institutes or universities with experience in culturing cells, but not in culturing iPS cells and RPE; they needed to acquire not only the skills but also the habitus and ethos of a sommelier.[14]

In the small culturing room, expert iPS sommelier Nanami is sitting in front of a clean bench and demonstrating the culturing process to the novices. When she carries the dish from the CO2 incubator to the clean bench, she typically uses both hands to carefully hold it, securely but gently. Then she carries it very slowly, as if carrying a baby bird. Nanami teaches the novices how to hold the dish and how to pour the medium slowly and carefully into the dish when the cells are in a delicate condition. Again and again, she asks them to treat the cells politely and respectfully. One of the novices, Takuro, says to me, 'When I was culturing in my university,

12 If iPS cells are pluripotent, they can give rise to any kind of cell in the adult body, for instance skin cells, blood cells or neurons.

13 Murakami intentionally uses the word 'iPS sommelier' in relation with the first clinical study to transplant RPE-iPS cells to patients who have age-related macular degeneration. This is because iPS cells are still understudied. She emphasizes that skilled technicians are able to select good RPE-iPS cells. While wine sommeliers do not take care of wine or grapes, iPS sommeliers take care of cells. In this sense, iPS sommeliers are different from wine sommeliers.

14 I use the words 'habitus' in the Maussian sense (1973) and 'ethos' in the Weberian sense (2001).

nobody told me that cells were *kawaii* [cute]. It is the first time I've been taught how to treat cells respectfully and with affection.'

Nanami later says, 'I can't work with someone who doesn't feel that cells are *kawaii*. In recruitment interviews, I always ask interviewees whether they feel cells are *kawaii* or not'. Her characterization of this core attitude exemplifies how affective and aesthetic dimensions are essential for noticing subtle differences in the intracellular state of cells as well as their intercellular interactions. As she talks, her facial expression becomes more and more animated and I clearly see how affect and aesthetic sensibility are key to recognizing the subtle changes in cells, an ability that is necessary to this work. Discussing the relationship between cuteness and avant-garde poetics, literary critic Sianne Ngai (2005) used aesthetic concepts to analyze *kawaii*. Using examples such as the teddy bear and the artworks of Japanese artists Yoshitomo Nara and Takashi Murakami, she argues that *kawaii*, is not only associated with smallness, compactness, softness, but also helplessness and vulnerability. Of course, cells are tiny, sensitive, and vulnerable. Aesthetic analysis, however, pays less attention to the relational and interactive side, that is, the personal experience of *kawaii*. Just as a female protein crystallographer may be 'affecting and affected' during the scientific process (Myers 2008), the sense of *kawaii* is also acquired and cultivated during care. Genevieve Teil and Antoine Hennion (2004) discuss amateurs (music and food lovers) daily practices and argue that not only the body but also emotion and sensation are 'a result emerging from the activity of tasting' (2004: 32). Looking at the process of becoming an iPS sommeliers it will become clear how seeing and culturing cells evokes and strengthens sensations of *kawaii*, love, attachment, and cathexis[15].

When my fieldwork in the cultivation room began, I was unable to see the subtle differences between cells. I would peer down the microscope as laboratory members showed me petri dishes with cells at different stages of development. But no matter how carefully they described the features, they all looked the same to me. Then, one day, one of the iPS sommeliers, Wataru, told me that to him 'cells have a face':

> Well, I can't explain it very well, but I see their faces, as I see the faces of my friends or pets. When you see their faces, you know whether they're well or not. If you see your friend with a sad face, you think something's happened to him. Of course, some people don't realize that, you know. It's the same with cells.

Even though a cell has no eyes, nose or mouth, Wataru continued, some people can still recognize the 'faces', 'expressions', and 'moods' of cells and, interpreting

15 Cathexis is a term from phychoanalysis. According to the Oxford English Dictionary, it denotes 'the concentration of mental energy on one particular person, idea or object'.

these, are able to make informed judgments about timing for replenishing or replacing the medium[16] for passage[17] or for stocking.[18] This cathexis enables them to take care of the cells.

By differentiating RPE from iPS cells, scientists are able to grow RPE in dish (*in vitro*) that closely resembles RPE in the human body (*in vivo*). To check whether the cells being cultured are iPS cells or RPE cells, they sometimes check cell gene expression and function: for iPS cells, they check pluripotency markers[19]; for RPE, they check features such as pigmentation, gene expression, and the concentration of specific proteins.[20] But during cell culture, neither the time nor the resources are available to check these at each stage. In most cases, iPS sommeliers depend on sensory discrimination.

Aside from the formal protocols, in which procedures are systematically listed, iPS sommeliers judge cell moods based on experience and perception. Using onomatopoeia to express the conditions of cells, iPS sommeliers might describe them as *pichi-pichi* [lively], *pika-pika* [bright], *puri-puri* [plump] or *tsuya-tsuya* [glossy]. Nanami uses various kinds of onomatopoeia when she is satisfied with or excited about the cell condition. Her attitude dramatically changes depending on the condition of cells under her care: her mood swings from happy—when the cells thrive—to sad—when the cells are suffering.

Learning Culturing and Onomatopoeia

To get a deeper understanding of the process of cell culturing, I decided to learn some of the techniques. Miki, another iPS sommelier, agreed to teach me. Explaining that caring for iPS cells is too difficult for a beginner, Miki started me off with simpler STO cells, mouse fibroblasts, that are responsible for making the extracellular matrix and collagen inside bodily tissues. Miki handed me the protocol, a list of procedures, and demonstrated how to transfer cells from one medium to another. Trying to memorize the protocol and do as Miki showed me, my attention was initially focused on the technicalities, for instance, how to use the pipette or how to keep my hands and tools clean.

16 Cell-culture media, which contains nourishment and special chemicals to support the growth of cells has to be periodically changed or topped up.
17 Passage refers to the transfer of cells to other dishes. When cells increase and fulfill the current, they need to be reseeded in another dish at an appropriate density.
18 Cells may be refrigerated for storage.
19 Pluripotency markers include OCT3/4, NANOG, SSEA4 and TRA-1- 60.
20 PRE markers include PAX6, MITF, BEST1, PRE65, and ZO-1.

Before long, I realized that observation, however, is one of the most important things to learn. On the second day, Miki proposed taking photographs so we could compare my cells with hers. Looking through the microscope, I described my impression of the cells to Miki, unthinkingly using onomatopoeia.

> Oh! Your cells seem *nobi-nobi* [relaxed]. But my cells seem *gyuu-gyuu* [densely packed] and these, here and there, are *suka-suka* [too much space around them].

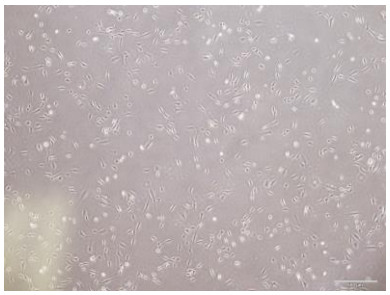

Figure 1: Miki's cells: *nobi-nobi*

Figure 2: Author's cells: *suka-suka*

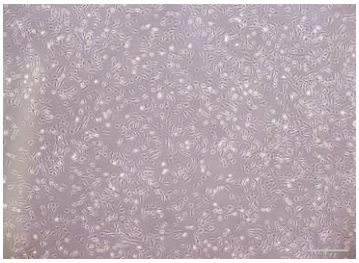

Figure 3: Author's cells: gyū-gyū

Several hours after we had transferred the STO cells, they stuck to the bottom of the dish, then elongated and proliferated. Generally speaking, if the density of the cells is too high, they cannot elongate, whereas if it is too low, they cannot proliferate. This is because STO cells help each other grow. Consequently, the *gyū-gyū* and *suka-suka* state of my cells was less than optimal. Through my apprenticeship in culturing and my unreflective adoption of onomatopoeia, I began to understand something not only about the adequate density of cells, but also about their affective embodiment. I learned to appreciate their embodiment by beginning to allow my own body to become affected by their actions.

The Japanese language is rich in onomatopoeia. Not only does it have *giongo* (擬音語), words that mimics sound, but also *gitaigo* (擬態語), words that denote non-auditory sensations. When describing the condition of cells, iPS sommeliers and I often used *gitaigo*. Japanese psycholinguist Sotaro Kita (1997) argues that Japanese onomatopoeia are similar to gestures. He suggests that mimetic words in Japanese 'evoke a vivid "image" of an experience, full of affect' (1997:

386). Indeed, he proposes that the semantics of onomatopoeia belongs to the affecto-imagistic dimension.[21] Furthermore, Japanese philosopher Kiyokazu Washida (2011) has analyzed Japanese onomatopoeia and its embodiment from the point of view of phenomenology. According to Washida, *gitaigo* describe human and non-human behaviors using sound. In other words, the visual sense is transformed into auditory sense. At the same time, the use of *gitaigo* directly conveys our feeling in an abstract manner. Uttering and hearing onomatopoeia may help to prime us to face the world and direct our attention, bodies and senses to certain aspects of it. In this sense, as Washida points out, *gitaigo* vocabulary overlaps different sensory modalities, including the visual, the spatial, and the auditory.

This leads us back to Natasha Myers's study of the physical gestures of protein crystallographers, one of whom, she explains, 'feels the spatiality and temporality of the molecule by virtue of the spatiality and temporality of her own body' (2008: 187). She called this gestural care 'molecular embodiment.' While iPS sommeliers may use physical gestures to express the condition of cells, they also often use onomatopoeia to effectively express the spatiality and temporality of cells. As we will see in the following examples, consideration of *gitaigo* may help us to better understand the relationship both between embodiment and knowledge production and between language and affect.

In addition, it is worth noting that Japanese onomatopoeia has a loose normativity that enables speakers of Japanese to create new readily understandable onomatopoeia on the spot (Natsume 2013). This flexibility of onomatopoeia enables iPS sommeliers to improvise onomatopoeia and, in this way, to extend the range of descriptors available to express the dimensional states of living cells. For instance iPS sommeliers say *puri-puri* (plump) to describe healthy cells. When, tripping at the middle plosive, they say *purippuri* (extremely plump), i.e. the condition is great. Sometimes they directly personify, by adding a term of address, for example, *puri-puri chan* (plump-*chan*). '*Chan*' is used as a diminutive suffix for a little girl or boy to show attachment and friendliness. Observing through the microscope, they may make up new onomatopoetic descriptors to express the current cell condition. This flexible use of improvisational onomatopoeia enables the description of, and affective adjustment to, various cells conditions.

Interestingly Ngai also points out the relationship between *kawaii* and onomatopoeia. She argues that 'the cute object shows its ability to infantilize the language of its infantilizer, dissolving syntactic divisions and reducing one's lexicon to onomatopoeia' (2005: 827). Since cells evoke a *kawaii* response from

21 Onomatopoeia may have continuity, however, with the 'analytic dimension' to which general language belongs (Kita 1997).

iPS sommeliers they use onomatopoeia spontaneously, without thinking. I contend, however, that the vocabulary of onomatopoeia is not infantilizing. Rather, it is an essential part of the process whereby the researcher embodies the condition of cells and accumulates knowledge and experience. Onomatopoeia is a way to share common understanding of the current state of cells. In the cell culture room, novices repeatedly examine cells through a microscope and listen to onomatopoetic descriptions uttered by highly skilled iPS sommeliers. Sometimes novices make memos, noting the '*pichi-pichi*' or '*bara-bara*' comments made by the sommeliers. By doing so, the novices enhance their mode of seeing and share the onomatopoeia as a form of collaborative work.

Second, besides functioning inter-personally, onomatopoeia enables transcendence of different sensory modalities within one person. When learning how to culture cells, technicians focus on improving their manipulative skills. But they also have to learn to be affected by the subtle response of the cells. During my training, Miki gave me technical instructions on how to maintain an even density in sample dishes and how to dissociate cell colonies into single cells. The cells were easily affected by my general manipulations, my handling of the pipettes and of the dishes. Gradually, I learned how my hand movements could affect the cells. At the same time, my own body and my emotions were becoming affected by the responses of the cells. Onomatopoeia helped me to memorize and consolidate in my body a sense of the subtle differences presented by cells: in a synesthetic way, the mimetic words bridged my sense of hearing, sense of sight, and sense of touch. Through the learning process, I began to appreciate that cells are indeed *living beings*. Thus, the gestural effects of onomatopoeia enable the qualities of cells to enter into our body.[22] Highly skilled iPS sommeliers seem able to use onomatopoeia to make fine distinctions between cell states and increase their sensitivity to the condition of cells.

Indeed, onomatopoetic words can be voiced representations of the cells themselves. In contrast to 'graphemes' in a 'scientific tracing-game' (Rheinberger 1997), they reflect the specificity of the experimental system of regenerative medicine. Rheinberger has argued that in experimental systems, scientific practice centers on the creation of graphemes, material traces of the object of inquiry located between theory and reality. Nature becomes real as a model. In the process of modeling, graphemes are the products of experimental arrangement and inscription devices which construct models. He gives examples of graphemes such as 'stained,

22 Onomatopoeia bear some resemblance to a special metaphorical 'craft language.' Japanese scholar of education, Kumiko Ikuta (1990) analyzes the roles of craft language in learning traditional Japanese performance such as Japanese dancing in Noh or Kabuki plays.

fluorescent, absorbent, or radioactive spots' (1997: 111) in chemical biology. By contrast, in the experimental system of regenerative medicine, the activity of the iPS sommeliers does not converge upon models. Rather, iPS sommeliers need to make cells, spotting subtle differences in cell condition and continuously responding to the unexpected behavior of cells. In other words, rather than proceeding by abstraction to model and theory, iPS sommeliers must respond ad hoc to each cell culture issue as it arises. Thus, the 'affecting and affected relationship' generated in these procedures is not static, rather it is an open-ended process of temporal emergence. Onomatopoeia is another type of sign or representation, possibly more dynamic than graphemes. The flexibility, multiplicity, and plasticity of onomatopoeia have enabled iPS sommeliers to invent a new mode of seeing and articulating their emergent and initially inchoate perceptions regarding the living cells they see under the microscope. In a loop of seeing, using onomatopoeia and manipulating technological systems, their bodies 'became articulated'.

Affective Entanglement

Myers and Dumit (2011) argue that 'capacity to be affected is acquired over time' (2011: 252), and time is essential for technicians to become skilled iPS sommeliers. To a point, the longer they culture cells, the stronger their affect becomes. Eventually, through 'becoming with' (Haraway 2008), cells and iPS sommeliers become attuned to each other. I realized that within several weeks of starting their training novices were rhythmically responding to their cells' condition. At the same time, and through the same process as the scientists who are cultivating the cells, they are also cultivating themselves aesthetically, sensuously, mentally and physically.

Working to keep them that way, iPS sommeliers see it as a given that their cells will be in good condition and invest considerable time and effort in their care. Even cells in prime condition, however, can easily deteriorate. When this happens, iPS sommeliers and novices may also show negative feelings: sadness, anger, restlessness, and even hatred. One day, novice Tamami, was observing her cells through a microscope when she sighed deeply. Disappointed, she muttered to me, 'there are many bad cells. From last Friday, bad cells have increased. I'm so sad'. So saying, her thin shoulders drooped. Another day, Takuro, a novice mentioned earlier, was frustrated and annoyed because his cells were in poor condition. Some colonies had started to differentiate. He expressed his experience and feeling by referring to the cells he was culturing as delinquent daughters:

> Now I'm losing heart. I like round, fresh and succulent cells. But today's [Monday] cells are very different from Saturday's. It seems most of my

> daughters [cells] will rebel (グレる) soon. Once a few daughters rebel (不良娘), other daughters follow suit. Maybe tomorrow this daughter [cell] will rebel. Oh, my sweet daughters, what happened to you on Sunday [that made you rebel this way]?

As they accumulate experience and knowledge, the novices become strongly committed and attached to the cells. Thus the appearance of 'delinquent' cells forces them to confront the fact that their experience and skill is insufficient. Although they assume that they should know the underlying causes when cells turn bad, iPS sommeliers have usually no way to know why cells become delinquent. Cells can be affected by tiny incidents. The researchers express their lack of certainty with appeals to fortune: 'What rotten luck!' Or, 'Just my luck!' Unforeseen and perplexing occurrences make iPS sommeliers more emotional and the task of caring for cells even harder. In the Murakami Laboratory, all the iPS sommeliers are workaholics with a strong sense of responsibility to their job. Working with them, it quickly becomes clear that iPS sommeliers need not only love for and attachment to the cells, but also to be mentally and physically patient. In this sense, caring for cells demands emotional (e.g. Hochschild 1983) and affective labor (Clough and Halley 2007).

At the appropriate time, iPS sommeliers induce genes in skin cells. Afterwards, the cell condition tends to become unstable, often ruining the sommelier's efforts. Nanami called the behavior of the cells in this uncontrollable situation 'wild merry-making' (お祭り騒ぎ). During the 'wild merry-making', cells suddenly become *bara-bara* (scattered). Here and there in the dish, cells which have hitherto been stable and quiet, abruptly start acting strangely. These colonies begin to affect the others and the overall behavior of cells in the whole dish shifts. Once this final stage is reached, iPS sommeliers cannot do anything.

Life scientists normally use established cell lines for their experiments. Given the proper medium and routine handling, these cell lines will proliferate infinitely and with predictable characteristics (see Landecker 2007). New iPS cells from human skin cells or blood cells, however, must be established independently by laboratory workers. These initial cultures are known as primary cultures and their cultivation demands more skill than established cell lines. Furthermore the culture techniques required by iPS sommeliers is distinctly demanding because it takes about ten months to differentiate skin cells into iPS cells and then ultimately into RPE membranes for transplantation. Then, iPS sommeliers have to co-culture iPS cells with fibroblasts, which, like iPS cells, are derived from the transplant target's skin.[23] Thus, both iPS cells and fibroblast cell lines must be established and

23 In standard scientific experiments, because mouse fibroblasts are needed to support iPS cell growth, researchers culture mouse fibroblasts and iPS cells in the same dish. Those supportive cells

sustained. Ultimate success depends on the combination of both cell lines. Thus primary culture, co-culture, and the overall time it takes to culture the cells imposes onerous responsibilities on iPS sommeliers. These difficulties are compounded by the fact that cell behavior can vary widely depending on both donor cell characteristics and the skills of those doing the culturing. Through trial and error, iPS sommeliers accumulate experience, knowledge, and sensibilities finely attuned to the task. By affecting and being affected, iPS sommeliers learn the characters of the cells they work with and adjust their skills and bodies accordingly.

Seeing cells in wild 'merry-making'. Nanami says to me and the novices:

> They (the cells) are struggling! (こいつら、いま闘ってんねん！) … Whether they can be iPS cells or not depends on what happens from now on. When we see a colony at this stage, it can either collapse or become iPS cells. So I can't ease up just yet (こっちとしてもまだまだ気が抜けへんねん'.

Over and over, Nanami says that 'This is the final stretch (こっからが勝負やで)'. And, indeed, she is always struggling with the cells. Her use of onomatopoeia helps to strongly involve her affectively and kinetically, merging with the cells and becoming attuned with them. The boundary between the cells and the sommeliers' bodies becomes ambiguous. This recalls the discussions of Latour (2004), Myers and Dumit (2011), Teil and Hennion (2004) that envoke concepts of 'articulation', 'mid-embodiment', and 'co-production'. By affecting and being affected beyond subject and object, both passively and actively, iPS sommeliers and cells come to be cultivated by each other. Myers (forthcoming) mentions how a female crystallographer can be 'molecularized at the same time as her molecule becomes humanized'. In this case, iPS sommeliers can be *cellularized* at the same time their cells become *humanized*.

Conclusion

In this paper I discussed the ways in which scientists and technicians in the Murakami Laboratory care for and become attached to the cells they culture. One of the most important points in cultivating skills is learning to recognize subtle differences in the condition of cells. This is crucial because, affected by both the environment and the manipulations of iPS sommeliers, cells keep changing. They are living beings. Depending on the condition of the cells, iPS sommeliers adjust

are called 'feeders'. However, in the Murakami Lab, where iPS cells are cultured for human transplantation, they cannot use mouse fibroblasts and need to establish human fibroblasts from the patient. Recently, stem cell researchers have developed feeder-free cell culture techniques.

the handling of pipettes, the timing and the amount of chemicals and nutrients they add to the cell environments in petri dishes. Cells also respond directly to human manipulation. During care, onomatopoeia works as a linguistic tool for embodying images and for generating and expressing knowledge of cells. In this process, cells and technicians are both affecting and are being affected. This is what is indicated here by the term, 'care for the cells'[24].

In this paper I have tried to rethink the relationship between humans and cells by expanding the notion of experimental systems in the context of regenerative medicine. In the laboratory, living technology and iPS sommeliers interact dynamically, continually improvising in their practices with the aid of onomatopoeia. This process is similar to the 'dance of agency' described by Pickering (1995). Rather than endeavoring to dominate and control nature, by establishing affective ties and responding bodily and emotionally to the state of the bodies they cultivate and nurture, iPS sommeliers create new relationships between specific humans and nonhumans. This situation may be peculiar to the experimental system of the early stages of the emerging field of regenerative medicine. Rather than constructing a model, iPS sommeliers need to culture cells from transplantation targets. In addition, they have to acquire and apply various culturing techniques, including creation of primary cultures, co-culturing, and to successfully sustain culturing through the ten months that RPE cultures require. These demands and the dance of agency make iPS sommeliers more sensitive and flexible both to their own bodies and to cells. 'Sommelier' is used by iPS cell researchers as a metaphor: through culturing, cells and iPS sommeliers cultivate each others corporeal entities. As a result they affect the bodily actions, life processes, and capabilities of each other. Through practise, iPS sommeliers in fact become more skillful 'sommeliers'. Others have suggested that attachment and improvisational learning have key roles in scientific practice (e.g. Puig de la Bellacasa 2011; Myers & Dumit 2011). By emphasizing the part played by onomatopoeia, this paper brought to light another aspect of the relationship between knowledge making, language use, and embodiment.

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24 Rather than of their 'self' (pun on Foucault intended; Foucault 1984).

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